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The eastern Nearctic species *Rasvena terna* (Frison, 1942) (Plecoptera, Chloroperlidae)

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Abstract
New and prior valid records of the endemic eastern Nearctic species *Rasvena terna* (Frison, 1942) were compiled and a dot distribution map is provided. *Rasvena terna* is reported from Canada (Quebec) for the first time. External reproductive morphology of adult males and adult females were studied across this species range. Scanning electron microscopy images of reproductive structures and the larval mandible are presented for the first time.

Key words
Biogeography; United States; Canada; Appalachian Mountains.

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Introduction

Frison (1942) described *Chloroperla terna* from Vermont, noting similarities with reproductive structures of *Chloroperla* (Newman, 1836) (*sensu* Kimmins 1936). Paratypes were also included from New York and Tennessee. Ricker (1952) transferred the species to the new subgenus *Rasvena* based on the reduced folded anal region of the forewing. Illies (1966) elevated *Rasvena* to full generic status although Hitchcock (1974) retained the original nomenclature of *C. terna* without explanation.

Fiance (1977) provided the first descriptions and illustrations of the larvae and the first larval key to the eastern North American Chloroperlidae. Surdick (1985) placed *R. terna* in the new tribe Chloroperlini, with redescriptions and illustrations of adult males, adult females, and larvae. Surdick (1985) hypothesized that *Rasvena* either has a Beringian tie to an Asian ancestor or a Laurasian origin with a European ancestor. Neither hypothesis has been tested using modern phylogenetic methods. Full descriptions and illustrations of the larva were subsequently included in Stewart and Stark (1988, 2002). Descriptions of the larva, plus full descriptions and illustrations of both adult stages, were again presented in Surdick (2004). Little is known about larval biology aside from general associations with stream size, elevation, and when adults have been collected (Stewart and Stark 2002).

Rasvena is still monotypic and *R. terna* is a widespread Appalachian species (Surdick 2004, DeWalt et al. 2018). NatureServe (2017) has applied a global ranking of G4 (= Apparently Secure). Although *R. terna* has been included in species lists or noted as new records in several publications at various scales (i.e., state, region, park; Tarter and Kirchner 1980, Kondratieff and Kirchner 1988, Kondratieff et al. 1995, Grubbs 1996, Masteller 1996a, Tarter and Nelson 2006, Parker et al. 2007, Earle

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2009, Myers et al. 2011, Beaty 2015) it is uncommonly collected and is reported herein from Canada for the first time. Repeated collecting efforts in western Maryland during the 1990s failed to locate populations of this species (Grubbs 1997).

The intent of this paper was two-fold: (1) study and present scanning electron microscopy (SEM) images of the adult male and adult female external reproductive structures and larval mandible, and (2) provide updated distributional information. An exhaustive search was conducted, providing records from museum holdings, individual collections, and valid literature sources. A dot distribution map is included.

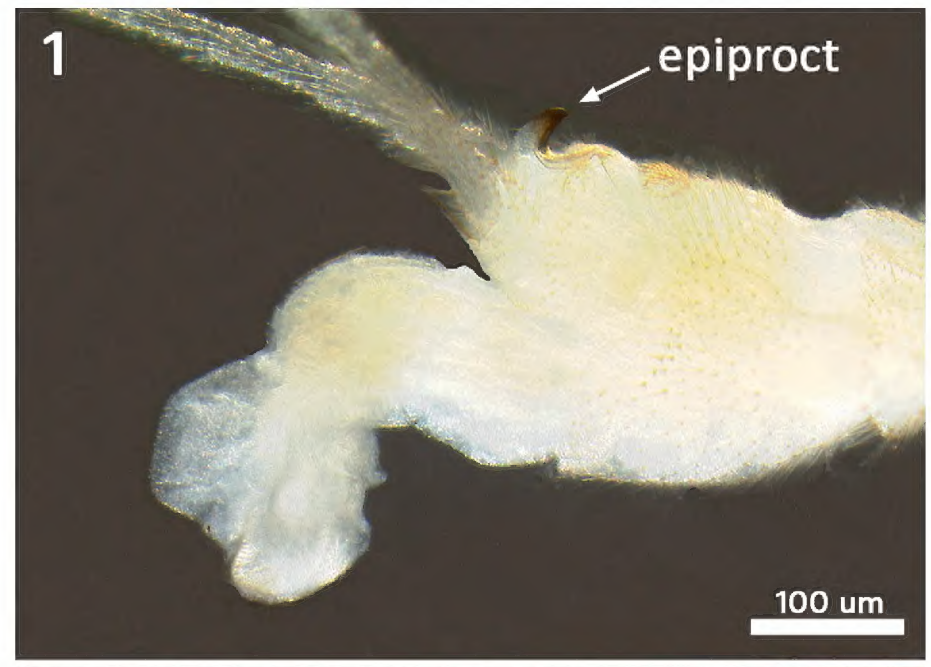
Methods

Specimens or specimen data were obtained from the following collections and institutions: Bill P. Stark Collection, Mississippi College, Clinton (BPSC), Monte L. Bean Museum, Brigham Young University, Provo, Utah (BYU), Charles H. Nelson Collection, Chattanooga, Tennessee (CHNC), Carnegie Museum of Natural History, Pittsburgh, Pennsylvania (CMNH), C.P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins (CSUIC), University of Tennessee, Knoxville (ECUT), Collections Preservation Center, Great Smoky Mountain National Park, Townsend, Tennessee (GRSM), Illinois Natural History Survey, Champaign (INHS), North Carolina Department of Environmental and Natural Resources, Division of Water Resources, Biological Assessment Branch, Raleigh (NCDWR), New York State Museum, Albany (NYSM), University of New Hampshire, Durham (UNHC), and Western Kentucky University, Bowling Green (WKUC). Specimen data were also integrated from valid literature sources. Locality data for all specimen records, in decimal degrees, were obtained either directly on site with GPS units or georeferenced from museum label data using Acme Mapper 2.1 (http://mapper.acme.com). All specimen data accrued and used during this project are archived in Darwin Core Archive file format supported by Pensoft's Integrated Publishing Toolkit (Grubbs 2018)

Adult male and female abdominal terminalia and larval mouthparts were prepared for SEM via serial dehydration in 75%, 95%, and 100% ethanol for 10 minutes each and hexamethyldisilizane for 30 minutes. Dehydrated specimens were attached to aluminum stubs with double-stick tape and coated with gold-palladium in an Emscope SC500. Coated specimens were examined using a Jeol JSM-6510LV scanning electron microscope and digital images were captured with an IXRF system.

Results

***Rasvena terna* (Frison, 1942)**
Vermont Sallfly
http://lsid.speciesfile.org/urn:lsid:Plecoptera.speciesfile.org:TaxonName:3391



Figures 1, 2. *Rasvena terna*, West Virginia, Hills Creek, male, aedeagus, lateral profile.

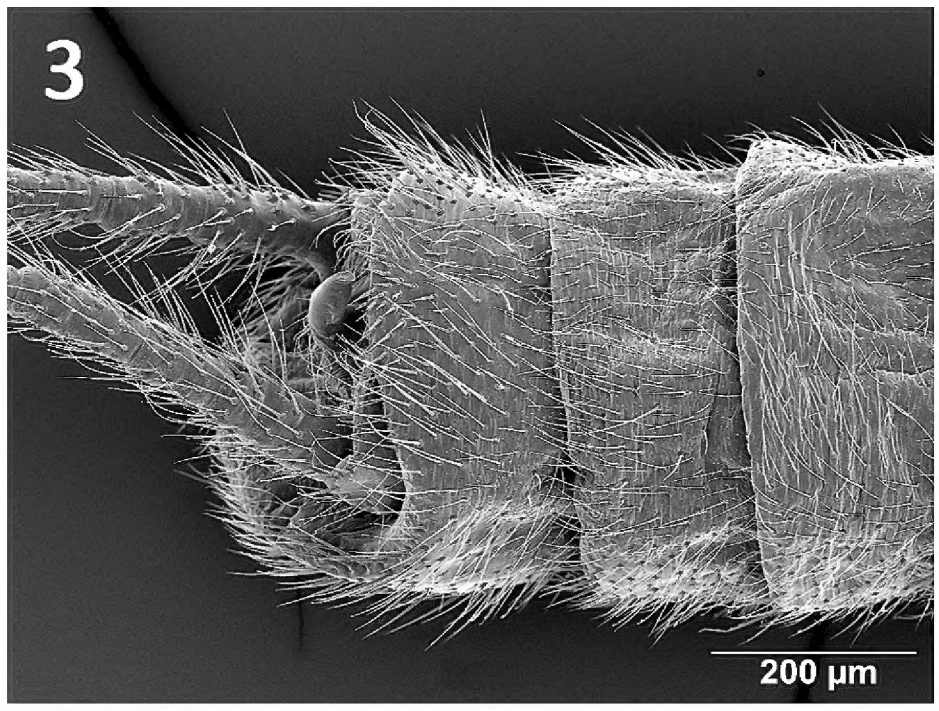
Figures 1–14, 18

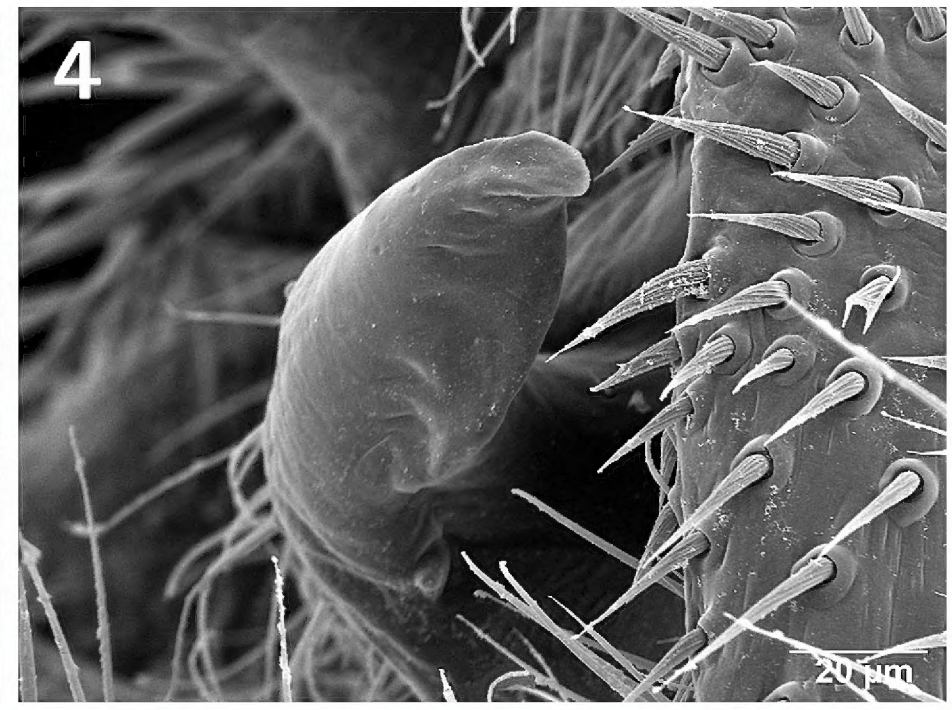
Chloroperla terna Frison 1942: 339. Holotype ♂ (Illinois Natural History Survey, Champaign, Illinois), Waits River, West Topsham (Orange Co.), Vermont (examined).
Chloroperla (*Rasvena*) *terna* Ricker 1952: 189.
Rasvena terna Illies 1966: 448.
Chloroperla terna Hitchcock 1974: 167.
Rasvena terna Fiance 1977: 313.
Rasvena terna Surdick 1985: 47.
Rasvena terna Stewart and Stark 1988: 243.
Rasvena terna Stewart and Stark 2002: 269.
Rasvena terna Surdick 2004: 35.

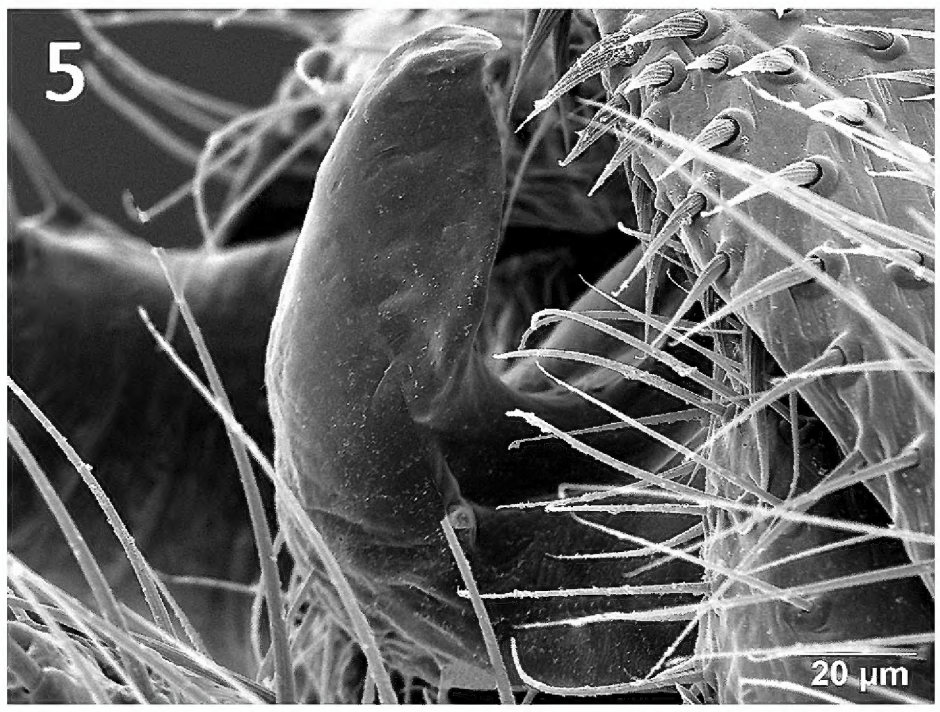
Distribution. USA: ME, NC, NH, NY, PA, TN, VA, VT, WV (DeWalt et al. 2018).

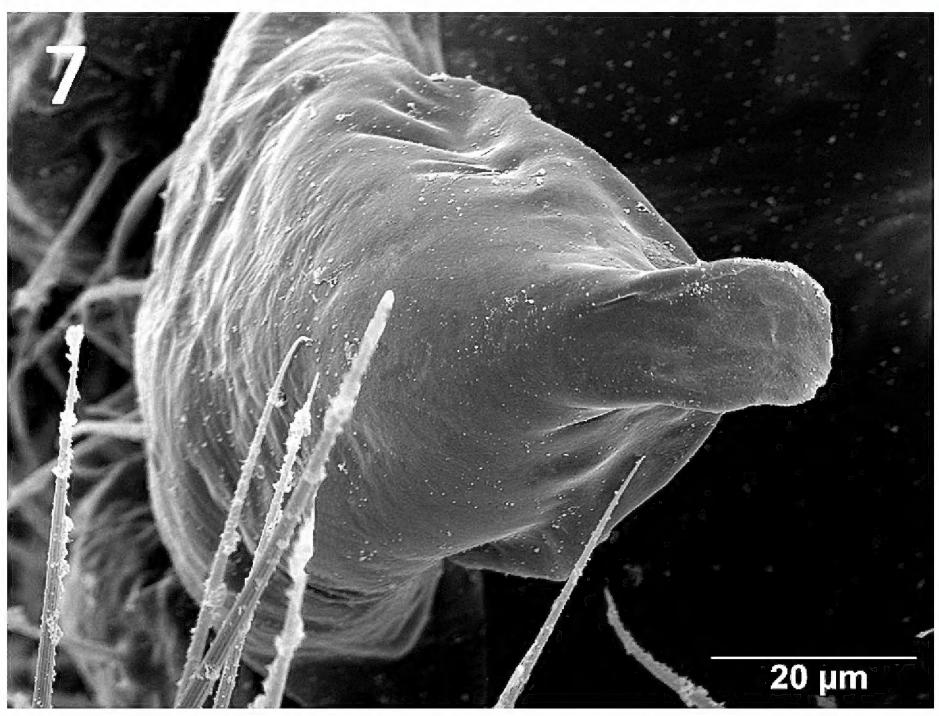
New records. Canada, Quebec, Riviere Remy, Rte 138, ca 4.0 mi. N Baie-St.-Paul, 47°31.56′N, 70°30.67′W, 10.vi.1997, S.A. Grubbs (1♂, WKUC). USA, Georgia, Habersham Co., Tallulah River, Tallulah Falls, 34°44.11′N, 83°23.10′W, 10.v.1944, T.H. Frison and H.H. Ross (1♀, INHS Plecoptera 15959). Massachusetts, Franklin Co., Whately Glen, Whately, 42°27.87′N, 72°39.01′W, 19.v.1939, J.F. Hanson (1♂, CHNC).

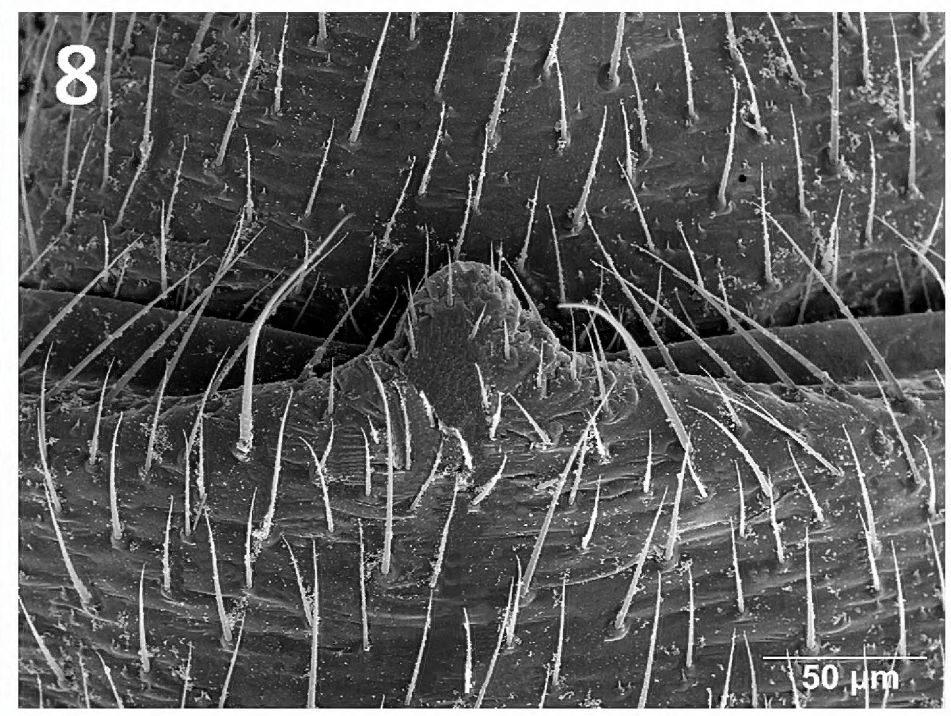
Additional material examined. USA, New Hampshire, Coös Co., Mill Brook, 3.2 km SE Meadows, 44°20.78′N, 71°27.44′W, 20.v.2009, D.S. Chandler and E. Wolff (1♂, UNHC); East Branch Mill Brook, 5 km SE Meadows, off of FR 93, 44°19.74′N, 71°26.31′W, 17.v.2010, D.S. Chandler and P. Teichholtz (1 larva, UNHC); Grafton





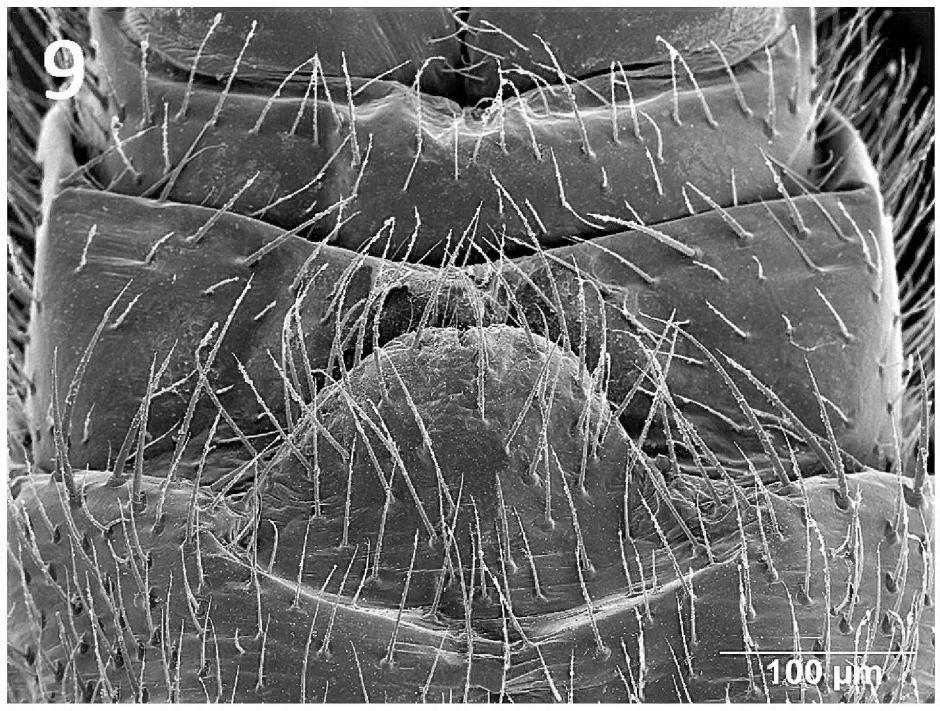


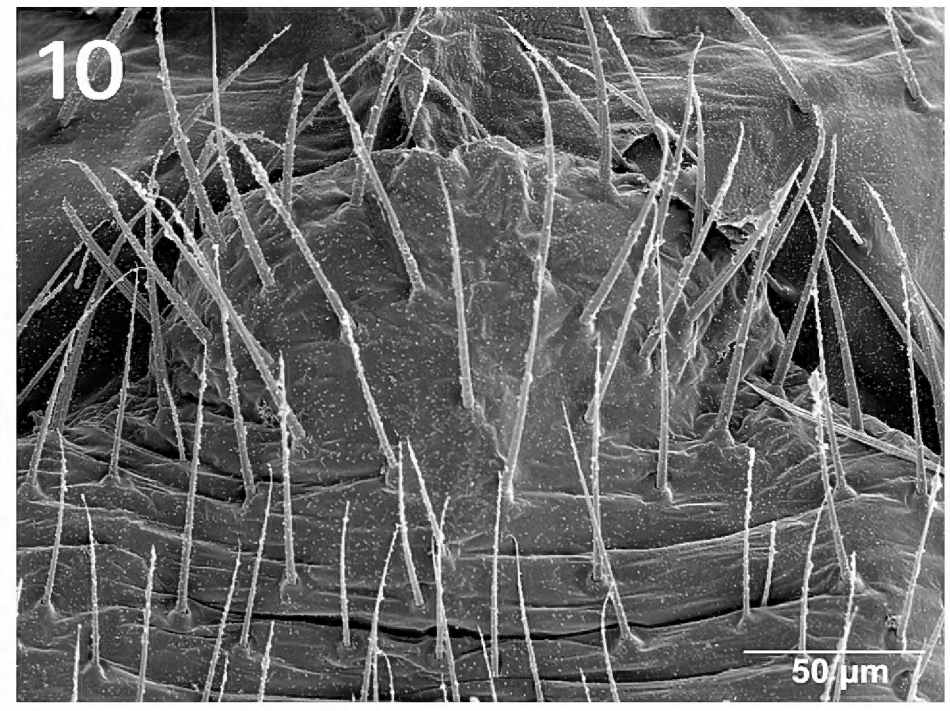




Figures 3–8. *Rasvena terna*, male. **3–7.** West Virginia, Hills Creek. **8.** North Carolina, Whitewater River. **3.** Abdominal terminalia, dorsolateral view. **4.** Epiproct, dorsolateral view. **5.** Epiproct, lateral view. **6.** Epiproct, partial dorsal view. **7**. Epiproct, dorsal view. **8**. 7th sternum vesicle, ventral view.

Co., Hubbard Brook, U.S. 3 N of Thornton, 43°55.96′N, 71°41.11′W, 28.v.1975, S.B. Fiance (1♂, 1♀, BYU). New York, Clinton Co., True Brook, True Brook Rd, 44°38.86′N, 73°51.22′W, 21.v.2006, L. Myers (3♀, NYSM); Essex Co., off Rte 9, Sidney E. Kerr bridge, Hale Brook Park, near Dearhead, 44°22.57′N, 73°33.97′W, 14.vi.1964, C.H. Nelson and D.W. Root (1♂, CHNC); East Branch Ausable River, Andrus Rd, Upper Jay, 44°20.14′N, 73°46.53′W, 21.v.2006, L. Myers (1♀, CSUIC); West Branch Ausable River, The Notch, Rte 86, 44°20.28′N, 73°53.73′W, 24.v.2006, L. Myers (2♂, 2♀, CSUIC); Stacy Brook, SW Westport, 44°08.95′N, 73°29.47′W, 23.v.2008, B.C. Kondratieff, R.W. Baumann, and L. Myers (1♂, 1♀, CSUIC); Rocky Branch, Nugent Rd, Jay Water Supply Tower, 44°20.92′N, 73°42.88′W, 25.vi.2008, L. Myers, T. Mihuc, and R. Mowrey (1♀, CSUIC). North Carolina, Avery Co., Elk Hollow Branch, off Roaring Creek Rd, 36°05.97′N, 82°02.73′W, 7.v.2015, M. Walters, V. Holland, and E. Fleek (2 larvae, NCDWR 11746); Cherokee Co., Peckerwood Creek, off FSR 420, near mouth, 35°15.71′N, 84°03.07′W, 21.iv.2009, S.R. Beaty, E. Fleek, and T.





Figures 9, 10. *Rasvena terna*, West Virginia, Hills Creek, female. **9.** Abdominal terminalia, ventral view. **10.** Subgenital plate flap, ventral plate.

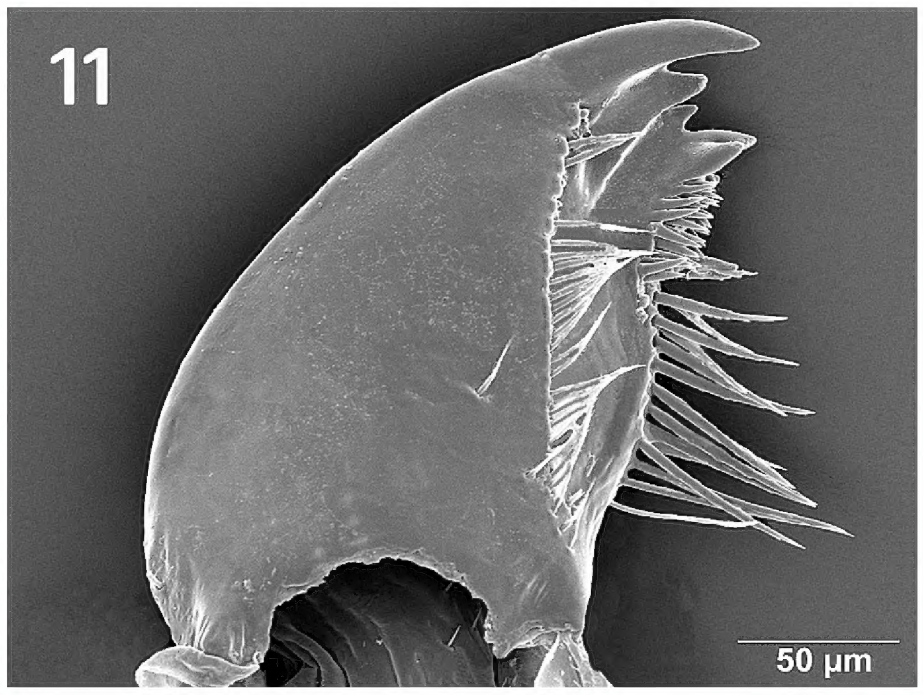


Figure 11. *Rasvena terna*, West Virginia, Hills Creek, larva, mandible, ventral view.

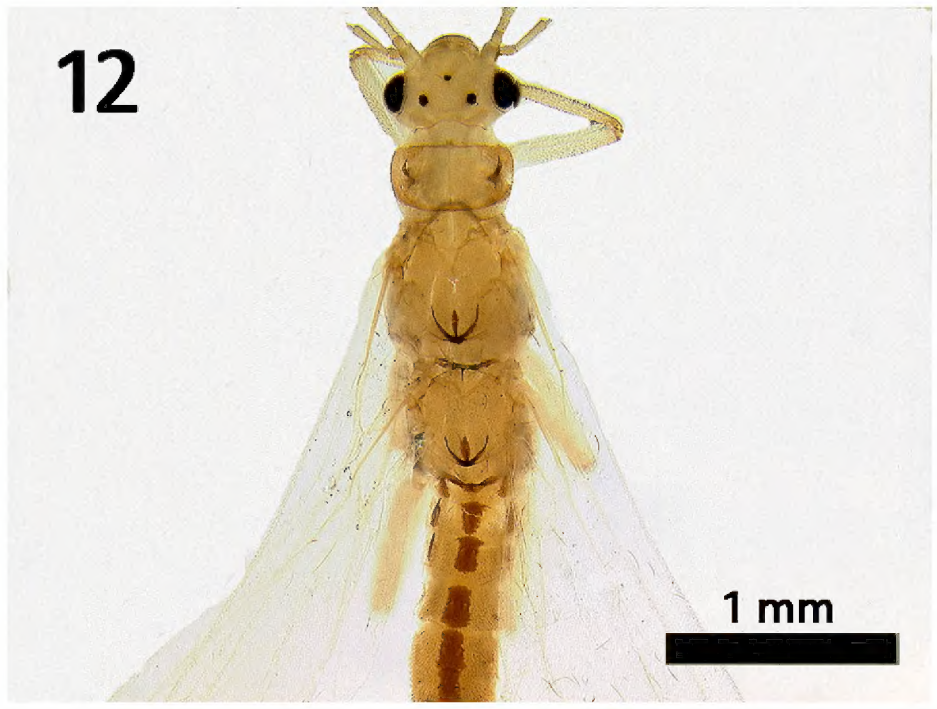
MacPherson (3 larvae, NCDWR 10630); Macon Co., Robin Branch, SR 1310, 35°09.22′N, 83°35.49′W, 5.iv.2014, S.R. Beaty, V. Holland, and E. Fleek (1 larva, NCDWR); Mitchell Co., Little Bear Creek, off NC 226, above Quarry, 35°56.58′N, 82°05.64′W, 20.iv.2010, S.R. Beaty, E. Fleek, and M. Walker (1 larva, NCDWR 10932); Transylvania Co., Log Hollow Branch, FSR 475B, 35°19.32′N, 82°48.17′W, 22.iv.2005, T. MacPherson (6 larvae, NCDWR 9601); Whitewater River, NC 281, 2 mi. S of Bohaynee, 35°02.25′N, 83°01.34′W, 20.iv.2007, B.C. Kondratieff, R.F. Kirchner, and D. Lenat (12♂, 3♀, CSUIC), same locality and collector data (5♂, BYU). Pennsylvania, Westmoreland Co., near Rector, 40°09.46′N, 79°16.46′W, 20.v.1956 (1♂, 1♀, CMNH). Vermont, Orange Co., Waits River, West Topsham, 44°07.22′N, 72°18.41′W, 21.vi.1942, T.H. Frison and H.H. Ross (holotype ♂, INHS Plecoptera 1448, paratype ♀, INHS Plecoptera 1449). Virginia, Wise Co., Phillips Creek, Phillips Creek Recreation Area, North Fork Pound Reservoir, 37°06.63′N, 82°40.35′W, 29.iv.1987, B.C. Kondratieff (3♂, CSUIC). West Virginia, Kanawha Co., spring-fed stream, near Paint Creek, Rd 83, Glenhuddy, 38°08.01′N, 81°23.44′W, 1.v.1987, B.C. Kondratieff and R.F. Kirchner (4♂, 2♀, CSUIC); Buzzard Branch, CR 83 S of Standard, 38°07.11′N, 81°23.13′W, 6.v.2005, B.C. Kondratieff, R.F. Kirchner, and R.E. Zuellig (1♀, CSUIC); Pocahontas Co., Hills Creek, Falls of Hill Creek Scenic Area, Monongahela National Forest, 38°10.42′N, 80°20.10′W, 15.v.1980, R.F. Kirchner and V.L. Worrell (5♂, 5♀, 2 larvae, BPSC), same locality and collector data (4♂, 2♀, CHNC), same locality data but 16.v.1981, R.F. Kirchner (5 larvae, BYU), same locality data but 14.v.1990, B.C. Kondratieff (7♂, 20♀, CSUIC), same locality data but 15.v.1990, B.C. Kondratieff and R.F. Kirchner (1♂, CSUIC), same locality data but 21.v.1999, B.P. Stark, R.F. Kirchner (2♀, BPSC).

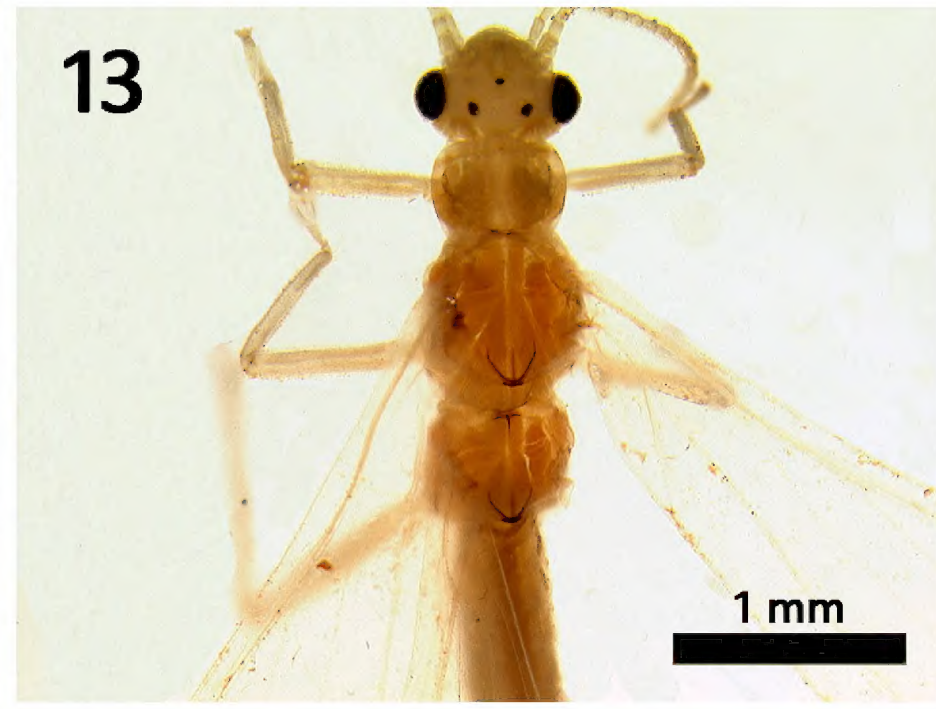
Amended description. *Male*: Described by Frison (1942) and subsequently in Surdick (1985, 2004). The anterior lobe of the aedeagus is tubular; the posterior lobe is slightly bulbous both dorsally and ventrally, bearing the paired, lightly sclerotized rods distally (Figs 1, 2). The epiproct tab is darkly sclerotized anteriorly and distally (Figs 1, 2). Under standard light microscopy the epiproct appears distally pointed (Figs 1, 2). Under SEM, in rotational aspects of lateral view the epiproct tab is distally subtriangular and very slightly concave (Figs 3–6); in dorsal view may appear subtruncate because the tab is downturned ventrally (Fig. 7). The vesicle on the 7th sternum is subtriangular (Fig. 8).

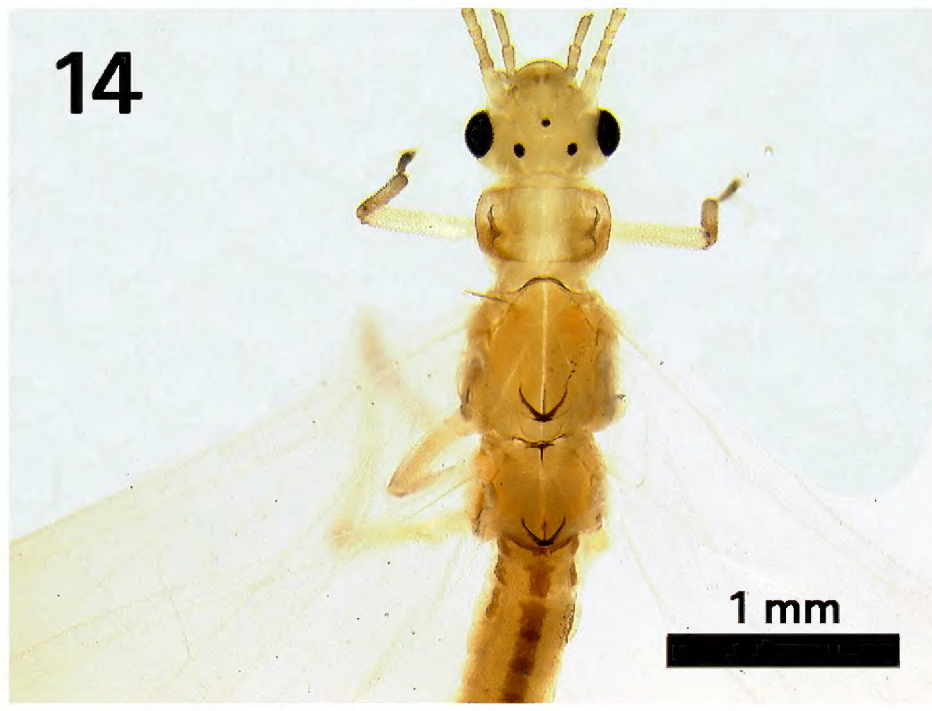
Female: Described by Frison (1942) and subsequently in Surdick (1985, 2004). The subgenital plate shown here with SEM depicts the appressed flap occupying the ca middle ⅓ of the 7th sternum and extending ca ¾ across the 8th sternum (Figs 9, 10).

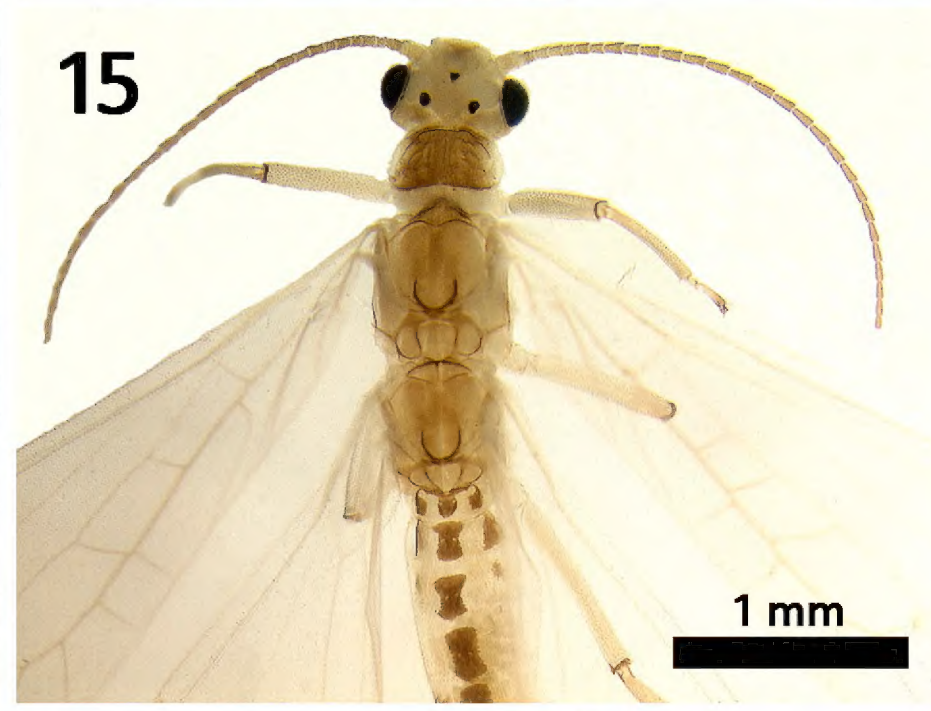
Larva: Described by Fiance (1977) and subsequently by Surdick (1985, 2005) and Stewart and Stark (1988, 2002). Mandibles lacking a ventral submarginal bristle patch is a diagnostic characteristic for *Rasvena* (Fig. 11; Stewart and Stark 2002: fig. 11.6C).

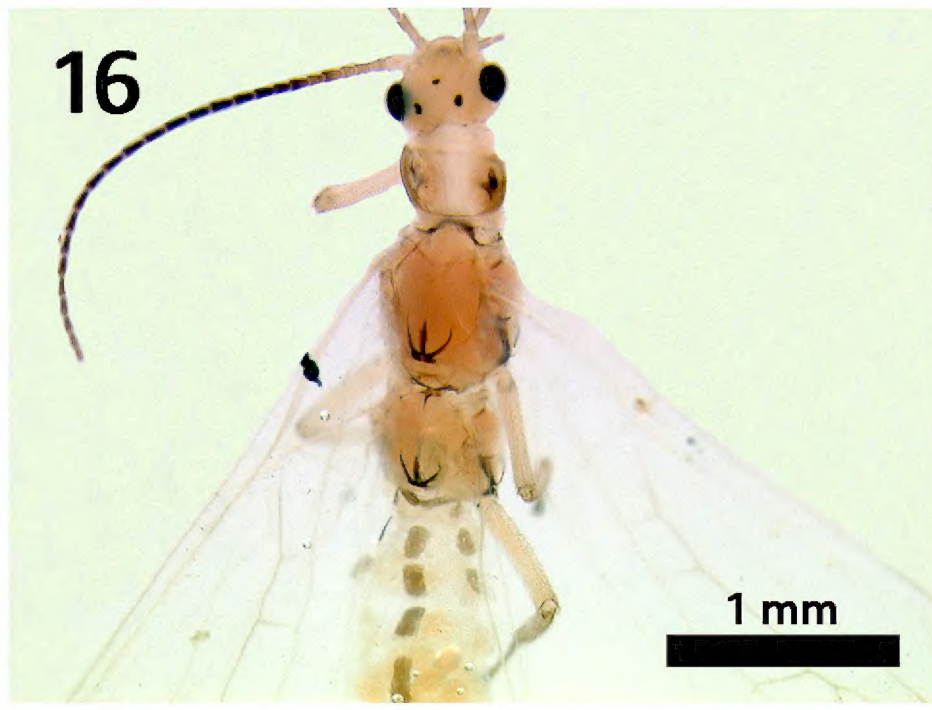
Diagnosis. The male epiproct of *R. terna* is consistent in shape and size across its range. The flap of the female subgenital plate exhibits only small differences in form, namely shape (Figs 9, 10) and extent across the 8th sternum. Adults of *Rasvena terna* (Figs 12–14) super-

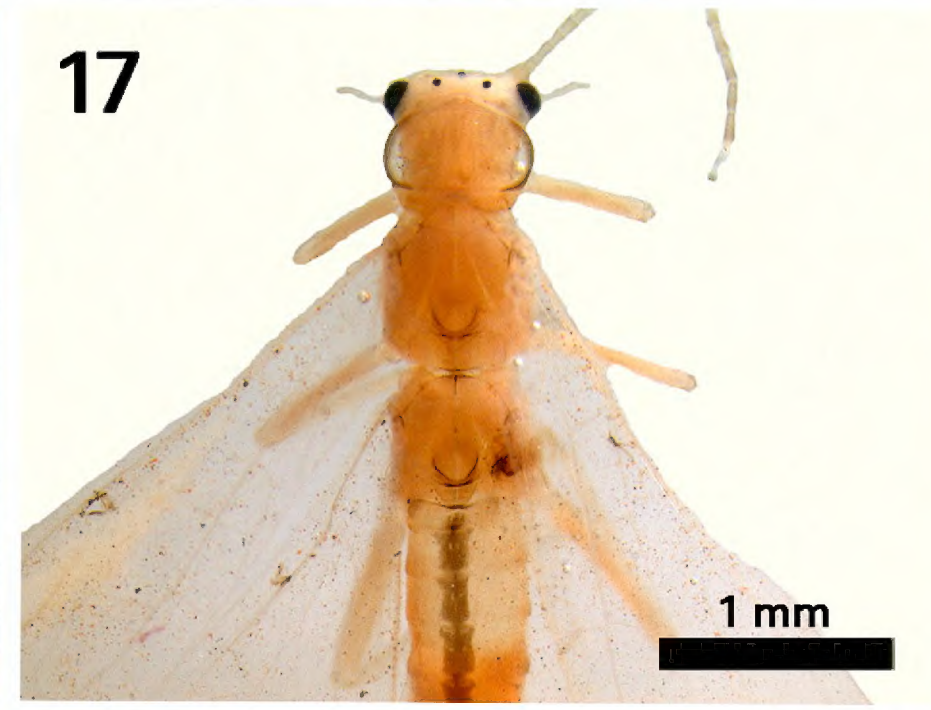












Figures 12–17. Adults, dorsal view. **12.** *Rasvena terna*, New York, East Branch Ausable River. **13.** *Rasvena terna*, Virginia, Phillips Creek. **14.** *Rasvena terna*, West Virginia, Hills Creek. **15.** *Alloperla nanina*, North Carolina, Haywood Gap Stream. **16.** *Haploperla orpha*, Maine, Penobscot County. **17.** *Suwallia marginata*, Maryland, Steyer Run.

ficially resemble other sympatric chloroperlid species (Figs 15–17) that have darkened pronotal margins and abdominal markings, especially on the anterior segments. For example, vials examined in this study had females of *Alloperla nanina* Banks, 1911 (Fig. 15), *Haploperla orpha* (Frison, 1937) (Fig. 16), and *Suwallia marginata* (Banks, 1897) (Fig. 17) all determined as *R. terna*.

Whereas the Rs vein of the hindwings of *H. orpha* (see Surdick 2004: fig. 6.273 for *H. brevis* (Banks, 1895)) and *S. marginata* are unbranched past the cord, this vein is branched both for *A. nanina* and *R. terna* (Surdick 1981: fig. 22, 2004: fig. 6.293). *Alloperla nanina* lacks darkened pronotal margins and its free triangular flap of the subgenital plate (Surdick 2004: fig. 6.36) is easily distinguished from the appressed, subtriangular flap of *R. terna* (Figs 9, 10; Surdick 1981: figs 152, 153, 2004: fig. 6.299).

The known distributions of *A. nanina*, *R. terna* (Fig. 18), and *S. marginata* generally overlap from northern Georgia northeastward through the Appalachian Mountains to southwestern Virginia. The known distributions of *H. orpha* and *R. terna* overlap from the Adirondack

Mountain region of upstate New York east to southern Quebec and Maine. Distribution information inferred from a collection label is insufficient for positive determination.

Discussion

The distribution as plotted herein for *R. terna* (Fig. 18) was based on material examined and valid literature records, but this should not be considered absolute or finite. For example, specimens from Maine were not immediately available for study but this species has been reported from this state (DeWalt et al. 2018). Only 37 individual vials in total were available for study. This is a sparse amount of material for a species with a broad Appalachian range extending approximately 2400 km along a straight line from northern Georgia to southern Quebec. Comprehensive examination of material housed in museums, state agencies and professional consulting

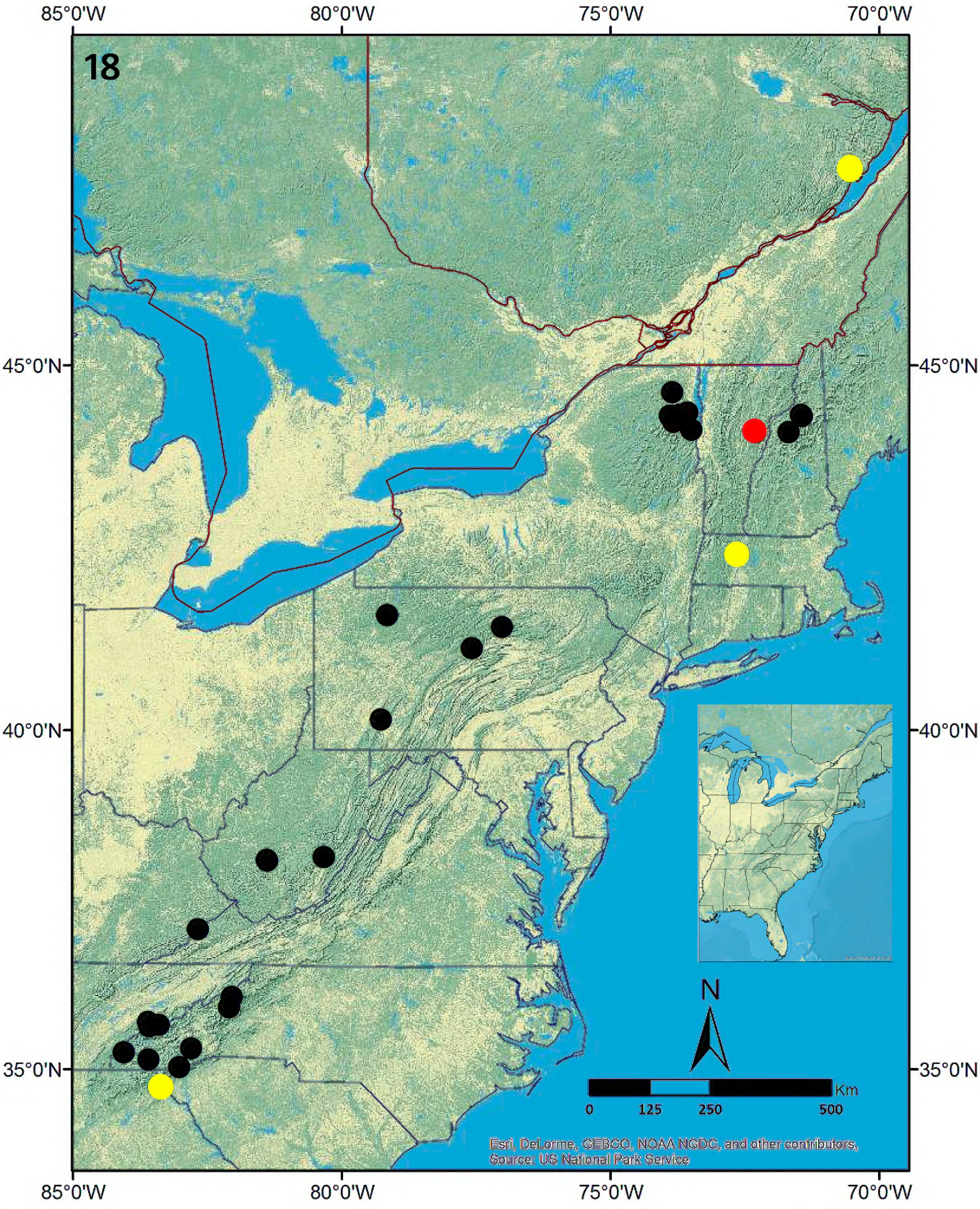


Figure 18. Distribution map of *Rasvena terna* based on material examined during this study and valid literature data. The red circle refers to the type locality. The three yellow circles refer to the new Canadian province and US state records.

firms, and private collections, together with fieldwork, should slowly expand our understanding of the distribution of this uncommon species.

Acknowledgements

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Authors' Contributions

SAG identified material and wrote text; SAG and MMS prepared images.

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